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(71) Applicant: QUALCOMM INCORPORATED [-/US]; 5775 Morehouse Drive, San Diego, CA 92121-1714 (US).

(72) Inventors: SINDHUSHAYANA, Nagabhushana, T.; 10615 Dabney Drive #19, San Diego, CA 92126 (US). ESTEVES, Eduardo, A., S.; 14005 H Mango Drive, Del Mar, CA 92014 (US).

(74) Agents: WADSWORTH, Philip, R. et al.; Qualcomm Incorporated, 5775 Morehouse Drive, San Diego, CA 92121-1714 (US).

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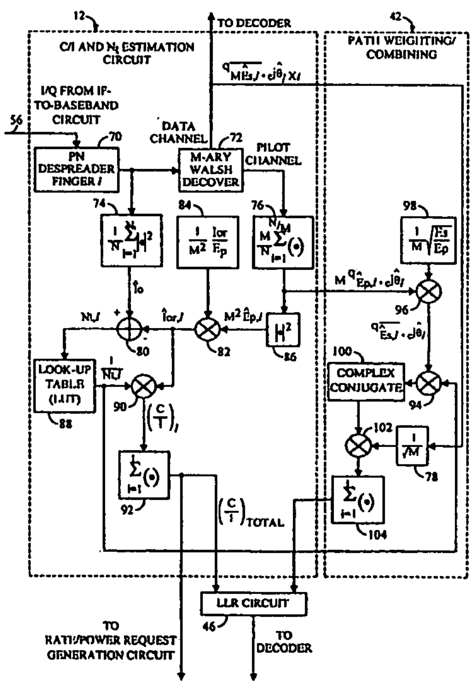
(54) Title: SYSTEM AND METHOD FOR PROVIDING AN ACCURATE ESTIMATION OF RECEIVED SIGNAL INTERFERENCE FOR USE IN WIRELESS COMMUNICATIONS SYSTEMS

(57) Abstract

A system for providing an accurate interference value signal received over a channel and transmitted by an external transceiver. The system includes a first receiver section for receiving the signal, which has a desired signal component and an interference component. A signal extracting circuit extracts an estimate of the desired signal component from the received signal. A noise estimation circuit (12) provides the accurate interference value based on the estimate of the desired signal component and the received signal. A look-up table transforms the accurate noise and/or interference value to a normalization factor. A carrier signal-to-interference ratio circuit employs the normalization factor and the received signal to compute an accurate carrier signal-to-interference ratio estimate. Path-combining circuitry generates optimal path-combining weights based on the received signal and the normalization factor.



SYSTEM AND METHOD FOR PROVIDING AN ACCURATE ESTIMATION OF RECEIVED SIGNAL INTERFERENCE FOR USE IN WIRELESS COMMUNICATIONS SYSTEMS

BACKGROUND OF THE INVENTION

I. Field of Invention:

This invention relates to communications systems. Specifically, the present invention relates systems for estimating the interference spectral density of a received signal in wireless code division multiple access (CDMA) communications systems for aiding in rate and power control and signal decoding.

II. Description of the Related Art:

Wireless communications systems are used in a variety of demanding applications including search and rescue and business applications. Such applications require efficient and reliable communications that can effectively operate in noisy environments.

Wireless communications systems are characterized by a plurality of mobile stations in communication with one or more base stations. Signals are transmitted between a base station and one or more mobile stations over a channel. Receivers in the mobile stations and base stations must estimate noise introduced to the transmitted signal by the channel to effectively decode the transmitted signal.

In a code division multiple access (CDMA) communications system, signals are spread over a wide bandwidth via the use of a pseudo noise (PN) spreading sequence. When the spread signals are transmitted over a channel, the signals take multiple paths from the base station to the mobile station. The

signals are received from the various paths at the mobile station, decoded, and constructively recombined via path-combining circuitry such as a Rake receiver. The path-combining circuitry applies gain factors, called weights, to each decoded path to maximize throughput and compensate for path delays and fading.

Often, a communications system transmission includes pilot interval, a power control interval, and a data interval. During the pilot interval, the base station transmits a pre-established reference signal to the mobile station. The mobile station combines information from the received reference signal, i.e., pilot signal, and the transmitted pilot signal to extract information about the channel, such as channel interference and signal-to-noise (SNR) ratio. The mobile station analyzes the characteristics of the channel and subsequently transmits a power control signal to the base station in response thereto during a subsequent power control interval. For example, if the base station is currently transmitting with excess power given the current channel characteristics, the mobile station sends a control signal to the base station requesting that transmitted power level be reduced.

Digital communications systems often require accurate log-likelihood ratios (LLRs) to accurately decode a received signal. An accurate signal-to-noise ratio (SNR) measurement or estimate is typically required to accurately calculate the LLR for a received signal. Accurate SNR estimates require precise knowledge of the noise characteristics of the channel, which may be estimated via the use of a pilot signal.

The rate or power at which a base station or mobile station broadcasts a signal is dependant on the noise characteristics of the channel. For maximum capacity, transceivers in the base stations and mobile stations control the power of transmitted signals in accordance with an estimate of the noise introduced by the channel. If the estimate of the noise, i.e., the interference spectral density of different multipath components of the transmitted signal is inaccurate, the transceivers may broadcast with too much or too little power. Broadcasting with too much power may result in inefficient use of network resources,

resulting in a reduction of network capacity and a possible reduction in mobile station battery life. Broadcasting with too little power may result in reduced throughput, dropped calls, reduced service quality, and disgruntled customers.

Accurate estimates of the noise introduced by the channel are also required to determine optimal path-combining weights. Currently, many CDMA telecommunications systems calculate SNR ratios as a function of the carrier signal energy to the total spectral density of the received signal. This calculation is suitable at small SNRs but becomes inaccurate at larger SNRs, resulting in degraded communications system performance.

In addition, many wireless CDMA communications systems fail to accurately account for the fact that some base stations that broadcast during the pilot interval do not broadcast during the data interval. As a result, noise measurements based on the pilot signal may become inaccurate during the data interval, thereby reducing system performance.

Hence, a need exists in the art for a system and method for accurately determining the interference spectral density of a received signal, calculating an accurate SNR or carrier signal-to-interference ratio, and determining optimal path-combining weights. There is a further need for a system that accounts for base stations that broadcast pilot signals during the pilot interval but do not broadcast during the data interval.

SUMMARY OF THE INVENTION

The need in the art is addressed by the system for providing an accurate interference value for a signal received over a channel and transmitted by an external transceiver of the present invention. In the illustrative embodiment, the inventive system is adapted for use with a wireless code division multiple access (CDMA) communications system and includes a first receiver section for receiving the signal, which has a desired signal component and an interference

and/or noise component. A signal extracting circuit extracts an estimate of the desired signal component from the received signal. A noise estimation circuit provides the accurate interference value based on the estimate of the desired signal component and the received signal. A look-up table transforms the accurate noise and/or interference value to a normalization factor. A carrier signal-to-interference ratio circuit employs the normalization factor and the received signal to compute an accurate carrier signal-to-interference ratio estimate. Path-combining circuitry generates optimal path-combining weights based on the received signal and the normalization factor.

In the illustrative embodiment, the system further includes a circuit for employing the accurate interference value to compute a carrier signal-to-interference ratio (C/I). The system further includes a circuit for computing optimal path-combining weights for multiple signal paths comprising the signal using the accurate interference value and providing optimally combined signal paths in response thereto. The system also includes a circuit for computing a log-likelihood value based on the carrier signal-to-interference ratio and the optimally combined signal paths. The system also includes a circuit for decoding the received signal using the log-likelihood value. An additional circuit generates a rate and/or power control message and transmits the rate and/or power control message to the external transceiver.

In a specific embodiment, the first receiver section includes downconversion and mixing circuitry for providing in-phase and quadrature signal samples from the received signal. The signal extracting circuit includes a pseudo noise despreader that provides despread in-phase and quadrature signal samples from the in-phase and quadrature signal samples. The signal extracting circuit further includes a decovering circuit that separates data signals and a pilot signal from the despread in-phase and quadrature signal samples and provides a data channel output and a pilot channel output in response thereto. The signal extracting circuit further includes an averaging circuit for reducing noise in the pilot channel output and providing the estimate of the desired signal component as output in response thereto. The

noise estimation circuit includes a circuit for computing a desired signal energy value associated with the estimate, multiplying the desired signal energy value by a predetermined constant to yield a scaled desired signal energy value, and subtracting the scaled desired signal energy value from an estimate of the total energy associated with the received signal to yield the accurate interference value.

An alternative implementation of the noise estimation circuit includes a subtractor that subtracts the desired signal component from the pilot channel output and provides an interference signal in response thereto. The noise estimation circuit includes an energy computation circuit for providing the accurate interference value from the interference signal.

The accurate interference value is applied to a look-up table (LUT), which computes the reciprocal of the interference power spectral density, which corresponds to the accurate interference value. The reciprocal is then multiplied by the scaled desired signal energy value to yield a carrier signal-to-interference ratio (C/I) estimate that is subsequently averaged by an averaging circuit and input to a log likelihood ratio (LLR) circuit. The reciprocal is also multiplied by path-combining weights derived from the pilot channel output to yield normalized optimal path-combining weight estimates, which are subsequently scaled by a constant factor, averaged, and input to the LLR circuit, which computes the LLR of the received signal.

The circuit for computing optimal path-combining weights for each multiple signal path comprising the received signal includes a circuit for providing a scaled estimate of the complex amplitude of the desired signal component from an output of a pilot filter and a constant providing circuit. The scaled estimate is normalized by the accurate interference value. A conjugation circuit provides a conjugate of the scaled estimate, which is representative of the optimal path-combining weights.

The novel design of the present invention is facilitated by the noise estimation circuit that provides an accurate estimate of an interference component of the received signal. The accurate estimate of the interference

component results in a precise estimate of carrier signal-to-interference ratio, which facilitates optimal decoding of the received signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a diagram of a telecommunications system of the present invention having an accurate interference energy computation circuit.

Fig. 2 is a more detailed diagram of the accurate interference energy computation circuit, log-likelihood ratio (LLR) circuit, and path-combining circuit of Fig. 1 adapted for use with forward link transmissions.

Fig. 3 is a diagram of an accurate interference energy computation circuit optimized for reverse link transmission and including the path weighting and combining circuit and the LLR circuit of Fig. 2.

Fig. 4 is a diagram showing alternative embodiments of the accurate interference energy estimation circuit and the maximal ratio path-combining circuit of Fig. 2.

Fig. 5 is a block diagram of a frame activity control circuit for improving estimates of interference energy and adapted for use with the accurate interference energy computation circuit of Fig. 2.

Fig. 6 is an exemplary timing diagram showing an active slot and idle slot.

Fig. 7 is an exemplary timing diagram showing a traffic channel signal, a pilot channel signal, a frame activity signal (FAC) (also known as a reverse power control channel), and idle channel skirts of the slots of Fig. 6.

DESCRIPTION OF THE INVENTION

While the present invention is described herein with reference to illustrative embodiments for particular applications, it should be understood that the invention is not limited thereto. Those having ordinary skill in the art

and access to the teachings provided herein will recognize additional modifications, applications, and embodiments within the scope thereof and additional fields in which the present invention would be of significant utility.

Fig. 1 is a diagram of a telecommunications transceiver system 10 of the present invention having an accurate carrier signal-to-interference (C/I) and interference energy (N_t) computation circuit 12. The system 10 is adapted for use with a CDMA mobile station. In the present specific embodiment, signals received by the transceiver system 10 are received over a forward communications link between a base station (not shown) and the system 10. Signals transmitted by the transceiver system 10 are transmitted over a reverse communications link from the transceiver system 10 to the associated base station.

For clarity, many details of the transceiver system 10 have been omitted, such as clocking circuitry, microphones, speakers, and so on. Those skilled in the art can easily implement the additional circuitry without undue experimentation.

The transceiver system 10 is a dual conversion telecommunications transceiver and includes an antenna 14 connected to a duplexer 16. The duplexer 16 is connected to a receive path that includes, from left to right, a receive amplifier 18, a radio frequency (RF) to intermediate frequency (IF) mixer 20, a receive bandpass filter 22, a receive automatic gain control circuit (AGC) 24, and an IF-to-baseband circuit 26. The IF-to-baseband circuit 26 is connected to a baseband computer 28 at the C/I and N_t estimation circuit 12.

The duplexer 16 is also connected to a transmit path 66 that includes a transmit amplifier 30, an IF-to-RF mixer 32, a transmit bandpass filter 34, a transmit AGC 36, and a baseband-to-IF circuit 38. The transmit baseband-to-IF circuit 38 is connected to the baseband computer 28 at an encoder 40.

The C/I and N_t estimation circuit 12 in the baseband computer 28 is connected to a path weighting and combining circuit 42, a rate/power request generation circuit 44, and a log-likelihood ratio (LLR) circuit 46. The LLR circuit 46 is also connected to the path weighting and combining circuit 42 and

a decoder 48. The decoder 48 is connected to a controller 50 that is also connected to the rate/power request generation circuit 44 and the encoder 40.

The antenna 14 receives and transmits RF signals. A duplexer 16, connected to the antenna 14, facilitates the separation of receive RF signals 52 from transmit RF signals 54.

RF signals 52 received by the antenna 14 are directed to the receive path 64 where they are amplified by the receive amplifier 18, mixed to intermediate frequencies via the RF-to-IF mixer 20, filtered by the receive bandpass filter 22, gain-adjusted by the receive AGC 24, and then converted to digital baseband signals 56 via the IF-to-baseband circuit 26. The digital baseband signals 56 are then input to a digital baseband computer 28.

In the present embodiment, the receiver system 10 is adapted for use with quadrature phase shift-keying (QPSK) modulation and demodulation techniques, and the digital baseband signals 56 are quadrature amplitude modulation (QAM) signals that include both in-phase (I) and quadrature (Q) signal components. The I and Q baseband signals 56 represent both pilot signals and data signals transmitted from a CDMA telecommunications transceiver such as a transceiver employed in a base station.

In the transmit path 66, digital baseband computer output signals 58 are converted to analog signals via the baseband-to-IF circuit 38, mixed to IF signals, filtered by the transmit bandpass filter 34, mixed up to RF by the IF-to-RF mixer 32, amplified by the transmit amplifier 30 and then transmitted via the duplexer 16 and the antenna 14.

Both the receive and transmit paths 64 and 66, respectively, are connected to the digital baseband computer 28. The digital baseband computer 28 processes the received baseband digital signals 56 and outputs the digital baseband computer output signals 58. The baseband computer 28 may include such functions as signal to voice conversions and/or vise versa.

The baseband-to-IF circuit 38 includes various components (not shown) such as digital-to-analog converters (DACs), mixers, adders, filters, shifters, and

local oscillators. The baseband computer output signals 58 include both in-phase (I) and quadrature (Q) signal components that are 90° out of phase. The output signals 58 are input to digital-to-analog converters (DACs) in the analog baseband-to-IF circuit 38, where they are converted to analog signals that are then filtered by lowpass filters in preparation for mixing. The phases of the output signals 58 are adjusted, mixed, and summed via a 90° shifter (not shown), baseband-to-IF mixers (not shown), and an adder (not shown), respectively, included in the baseband-to-IF circuit 38.

The adder outputs IF signals to the transmit AGC circuit 36 where the gain of the mixed IF signals is adjusted in preparation for filtering via the transmit bandpass filter 34, mixing up to RF via the IF-to-transmit mixer 32, amplifying via the transmit amplifier 20, and eventual radio transmission via the duplexer 16 and the antenna 14.

Similarly, the IF-to-baseband circuit 26 in the receive path 64 includes circuitry (not shown) such as analog-to-digital (ADC) converters, oscillators, and mixers. A received gain-adjusted signals output from the receive AGC circuit 24 are transferred to the IF-to-baseband circuit 26 where they are mixed to baseband via mixing circuitry and then converted to digital signals via analog-to-digital converters (ADCs).

Both the baseband-to-IF circuit 38 and the IF-to-baseband circuit 36 employ an oscillator signal provided via a first oscillator 60 to facilitate mixing functions. The receive RF-to-IF mixer 20 and the transmit IF-to-RF mixer 32 employ an oscillator signal input from a second oscillator 62. The first and second oscillators 60 and 6, respectively, may be implemented as phase-locked loops that derive output signals from a master reference oscillator signal.

Those skilled in the art will appreciate that other types of receive and transmit paths 64 and 66 may be employed instead without departing from the scope of the present invention. The various components such as amplifiers 18 and 30, mixers 20 and 32, filters 22 and 34, AGC circuits 24 and 36, and frequency conversion circuits 26 and 38 are standard components and may

easily be constructed by those having ordinary skill in the art and access to the present teachings.

In the baseband computer 28, the received I and Q signals 56 are input to the C/I and N_t estimation circuit 12. The C/I and N_t estimation circuit 12 accurately determines the interference energy of the I and Q signals 56 based on the pilot signal and determines a carrier signal-to-interference ratio in response thereto. The carrier signal-to-interference ratio (C/I) is similar to signal-to-noise ratio (SNR) and is the ratio of the energy of the received I and Q signals 56 less interference and noise components to the interference energy of the received I and Q signals 56. Conventional C/I estimation circuits often fail to accurately estimate the multipath interference energy.

The C/I and N_t estimation circuit 12 outputs a C/I signal to the rate/power request generation circuit 44 and the LLR circuit 46. The C/I and N_t estimation circuit 12 also outputs the reciprocal of the interference energy ($1/N_t$), a despread and decovered data channel signal, and a despread and decovered pilot channel signal to the path weighting and combining circuit 42. The despread and decovered data channel signal is also provided to the decoder 48 where it is decoded and forwarded to the controller 50. At the controller 50, the decoded signal is processed to output voice or data, or to generate a reverse link signal for transfer to the associated base station (not shown).

The path weighting and combining circuit 42 computes optimal ratio path-combining weights for multipath components of the received data signal corresponding to the data channel signal, weights the appropriate paths, combines the multiple paths, and provides the summed and weighted paths as a metric to the LLR circuit 46.

The LLR circuit 46 employs metrics from the path weighting and combining circuit 42 with the C/I estimation provided by the C/I and N_t estimation circuit 12 to generate an optimal LLR and soft decoder decision values. The optimal LLR and soft decoder decision values are provided to the decoder 48 to facilitate decoding of the received data channel signals. The

CLAIMS

1. A system for providing an accurate noise and/or interference value for a signal received over a wireless channel and transmitted by an external transceiver comprising:

a first code division multiple access receiver section for receiving said signal, said received signal having a desired signal component and an interference and/or noise component;

a signal extracting circuit for extracting an estimate of said desired signal component from said received signal;

a noise estimation circuit for providing said accurate noise and/or interference value based on said estimate of said desired signal component and said received signal;

a look-up table for transforming said accurate noise and/or interference value to a normalization factor;

a carrier signal-to-interference ratio circuit for employing said normalization factor and said received signal to generate an accurate carrier signal-to-interference ratio estimate; and

path-combining circuitry for generating optimal path-combining weights based on said received signal and said normalization factor.

2. The system of Claim 1 further including means for employing said accurate interference value to compute a carrier signal-to-interference ratio.

3. The system of Claim 2 further including means for computing optimal path-combining weights for multiple signal paths comprising said signal using said accurate noise and/or interference value and providing optimally combined signal paths in response thereto.

4. The system of Claim 3 further including means for computing a log-likelihood value based on said carrier signal-to-interference ratio and said optimally combined signal paths.

5. The system of Claim 4 further including means for decoding said received signal using said log-likelihood value.

6. The system of Claim 2 further including means for generating a rate and/or power control message and transmitting said rate and/or power control message to said external transceiver.

7. The system of Claim 1 wherein said first receiver section includes downconversion and mixing circuitry for providing in-phase and quadrature signal samples from said received signal.

8. The system of Claim 7 wherein said signal extracting circuit includes a pseudo noise despreader for providing despread in-phase and quadrature signal samples from said in-phase and quadrature signal samples.

9. The system of Claim 8 wherein said signal extracting circuit further includes a decovering circuit for separating a pilot signal and data signals from said despread in-phase and quadrature signal samples and providing a data channel output and a pilot channel output in response thereto.

10. The system of Claim 9 wherein said data channel output is described by the following equation:

$$s = \sqrt{M\hat{E}_{s,l}} \cdot e^{j\hat{\theta}_l} X_l,$$

where s represents the data channel, M is the number of chips per Walsh symbol; $\hat{E}_{s,l}$ is a modulation symbol energy of an l^{th} multipath component of

said data channel; $\hat{\theta}_l$ is a phase of the data channel s; and X_t is an information-baring component of said data channel s.

11. The system of Claim 9 wherein said signal extracting circuit further includes an averaging circuit for reducing noise in said pilot channel output and providing said estimate of said desired signal component as output in response thereto.

12. The system of Claim 11 wherein said estimate of said desired signal component is described by the following equation:

$$p = M\sqrt{\hat{E}_{p,l}} \cdot e^{j\theta_l}$$

where p represents said estimate; M is the number of chips per Walsh symbol; $\hat{E}_{p,l}$ is a pilot chip energy of an l^{th} multipath component of said estimate p; and θ_l is a phase of said estimate p.

13. The system of Claim 11 wherein said noise estimation circuit includes a circuit for computing an energy value associated with said estimate, multiplying said energy value by a predetermined constant to yield a scaled energy value, and subtracting said scaled energy value from an estimate of the total energy associated with said received signal to yield said accurate noise and/or interference value.

14. The system of Claim 13 wherein said predetermined constant is described by the following equation:

$$c = \frac{1}{M^2}\frac{I_{or}}{E_p}$$

where c represents said predetermined constant; I_{or} is the received energy of said desired signal component; and E_p is a pilot chip energy.

15. The system of Claim 13 wherein said accurate noise and/or interference value is applied to said look-up table, which computes a reciprocal

of said accurate noise and/or interference value to provide said normalization factor.

16. The system of Claim 15 wherein said noise estimation circuit further includes a multiplier for multiplying said scaled desired signal energy value by said normalization factor to yield said accurate carrier signal-to-interference ratio estimate.

17. The system of Claim 16 wherein said noise estimation circuit further includes an averaging circuit for averaging said carrier signal-to-interference ratio estimate and providing an averaged carrier signal-to-interference ratio estimate in response thereto.

18. The system of Claim 17 further including a log likelihood ratio circuit for computing a log likelihood ratio from said averaged carrier signal-to-interference ratio estimate and path-combining weights scaled by said normalization factor and averaged.

19. The system of Claim 11 wherein said noise estimation circuit includes a subtractor for subtracting said desired signal component from said pilot channel output and providing an interference signal in response thereto.

20. The system of Claim 19 wherein said noise estimation circuit includes an energy computation circuit for providing said accurate noise and/or interference value from said interference signal.

21. The system of Claim 1 further including means for computing optimal path-combining weights for each multiple signal path comprising said received signal.

22. The system of Claim 21 wherein said means for computing optimal path-combining weights includes means for providing a scaled estimate of an amplitude of said desired signal component from an output of a pilot filter and a constant providing circuit, said scaled estimate normalized by said accurate noise and/or interference value.

23. The system of Claim 22 wherein said scaled estimate is described by the following equation:

$$\hat{\alpha} = \sqrt{\hat{E}_{s,l}} \cdot e^{j\hat{\theta}_l} \Big/ N_{t,l},$$

where $\hat{\alpha}$ is said scaled estimate; $\hat{E}_{s,l}$ is an estimate of a modulation symbol energy of an l^{th} multipath component of said received signal; and $\hat{\theta}_l$ is an estimate of a phase of said output of said pilot filter, and $N_{s,l}$ is said accurate noise and/or interference value.

24. The system of Claim 23 further including a conjugation circuit for providing a conjugate of said scaled estimate, said conjugate representative of said optimal path-combining weights.

25. A system for providing an accurate interference value for a wireless signal received over a channel comprising:

first means for measuring an interference component of said received signal during a first time interval and providing an interference measurement in response thereto;

second means for determining a fraction of said interference component associated with signals transmitted during said first time interval and not to be transmitted during a subsequent time interval; and

third means for adjusting said interference measurement by said fraction and providing an adjusted noise measurement in response thereto as said accurate interference energy value.

26. A method for reducing inaccuracies in measurements of noise components of signals received over a channel comprising the steps of:

determining a multipath spread of said channel or an anticipated multipath spread of said channel and

transmitting an idle skirt signal before and after transmitting a pilot signal, said idle skirt signal having a length longer than said multipath spread of said channel or an anticipated multipath spread of said channel.

27. A system for providing an accurate interference energy value for a wireless signal received over a channel comprising:

a first receiver section for receiving said wireless signal and providing in-phase and quadrature signal samples from said wireless signal in response thereto;

a second receiver section for extracting a pilot signal from said in-phase and quadrature signal samples and providing an estimate of an energy of said wireless signal in response thereto, said estimate lacking an interference component; and

an interference calculation circuit for providing said interference energy value based on a measurement of a total energy of said wireless signal and said estimate of an energy of said wireless signal.

28. A system for providing an accurate carrier signal-to-interference ratio for facilitating the decoding of a signal received over a channel comprising:

means for receiving a signal over a channel, said received signal having one or more chips;

means for providing an estimate of total received energy per each of said one or more chips, said estimate of total received energy having an interference component and a desired signal energy component;

means for extracting from said received signal an estimate of said desired signal energy component;

means for employing said estimate of said desired signal energy component and said estimate of total received energy to provide an estimate said interference component; and

means for using said estimate of said desired signal energy component and said estimate of said interference component to provide said accurate carrier signal-to-interference ratio.

29. A system for providing optimal inputs to a log-likelihood ratio computation circuit comprising:

a first receiver section for receiving a signal over a channel;

an interference calculation circuit for providing a signal representative of interference and/or noise contained in said signal and providing a signal-to-interference ratio in response thereto;

an optimal path-combining circuit for employing said signal representative of interference and/or noise and said signal to produce an optimal path-combining signal as a first optimal input to said log-likelihood ratio computation circuit; and

an accumulating circuit for accumulating said signal-to-interference ratio to provide an optimal carrier signal-to-interference value as a second optimal input to said log-likelihood ratio computation circuit.

30. A communications system comprising:

a transceiver for transmitting a first signal over a channel at a predetermined rate and power level, said channel introducing noise and/or interference to said first signal;

means for receiving said first signal and providing in-phase and quadrature samples of said first signal in response thereto, said first signal having a pilot signal component and one or more multipath components;

means for extracting said pilot signal and providing an estimate of total interference energy received via said first signal on a predetermined multipath

component based on said pilot signal component and said in-phase and said quadrature samples;

means for generating a power or rate control signal based on said estimate of total interference energy and an estimate of energy associated with said one or more multipath components;

means for transmitting said power or rate control signal to said transceiver;

means for computing optimal path-combining weights for said one or more multipath components based on said estimate of total interference energy and providing optimally combined signal paths in response thereto;

means for computing a log-likelihood value based on said optimally combined signal paths, said total interference energy, and said estimate of energy associated with said one or more multipath components; and

means for decoding said first signal in response thereto.

31. A path weighting and combining circuit for determining maximal ratio path-combining weights for multiple paths of a received signal that has an interference component, a data component, and a pilot signal component comprising:

a separating circuit for separating said pilot signal component and said data component from said received signal;

a pilot filter for filtering said pilot signal to yield a filtered pilot signal;

an interference estimation circuit for estimating said interference component and providing an interference value in response thereto;

a first multiplier for multiplying said filtered pilot signal by a predetermined constant scaling factor and providing a scaled value in response thereto;

a second multiplier for multiplying said scaled value by a reciprocal of said interference value to yield a weighted signal; and

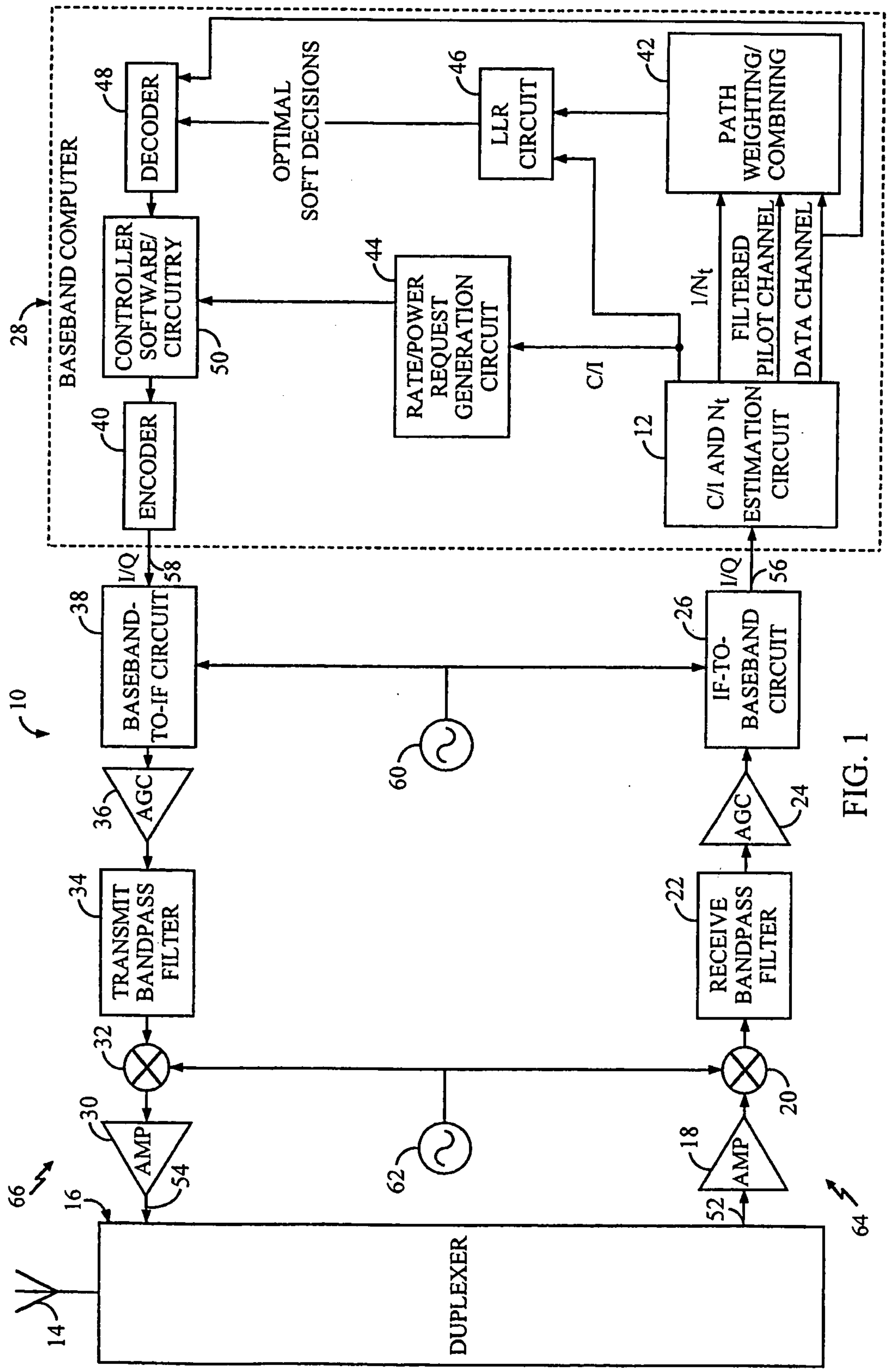
a conjugation circuit for computing a conjugate of said weighted signal to yield maximal ratio weights in response thereto.

32. A method for providing an accurate noise and/or interference value for a signal received over a channel and transmitted by an external transceiver comprising the steps of:

receiving said signal, said received signal having a desired signal component and an interference and/or noise component;

extracting circuit for extracting an estimate of said desired signal component from said received signal; and

providing said accurate noise and/or interference value based on said estimate of said desired signal component and said received signal.


BASEBAND COMPUTER
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DUPLEXER
14

FIG. 1

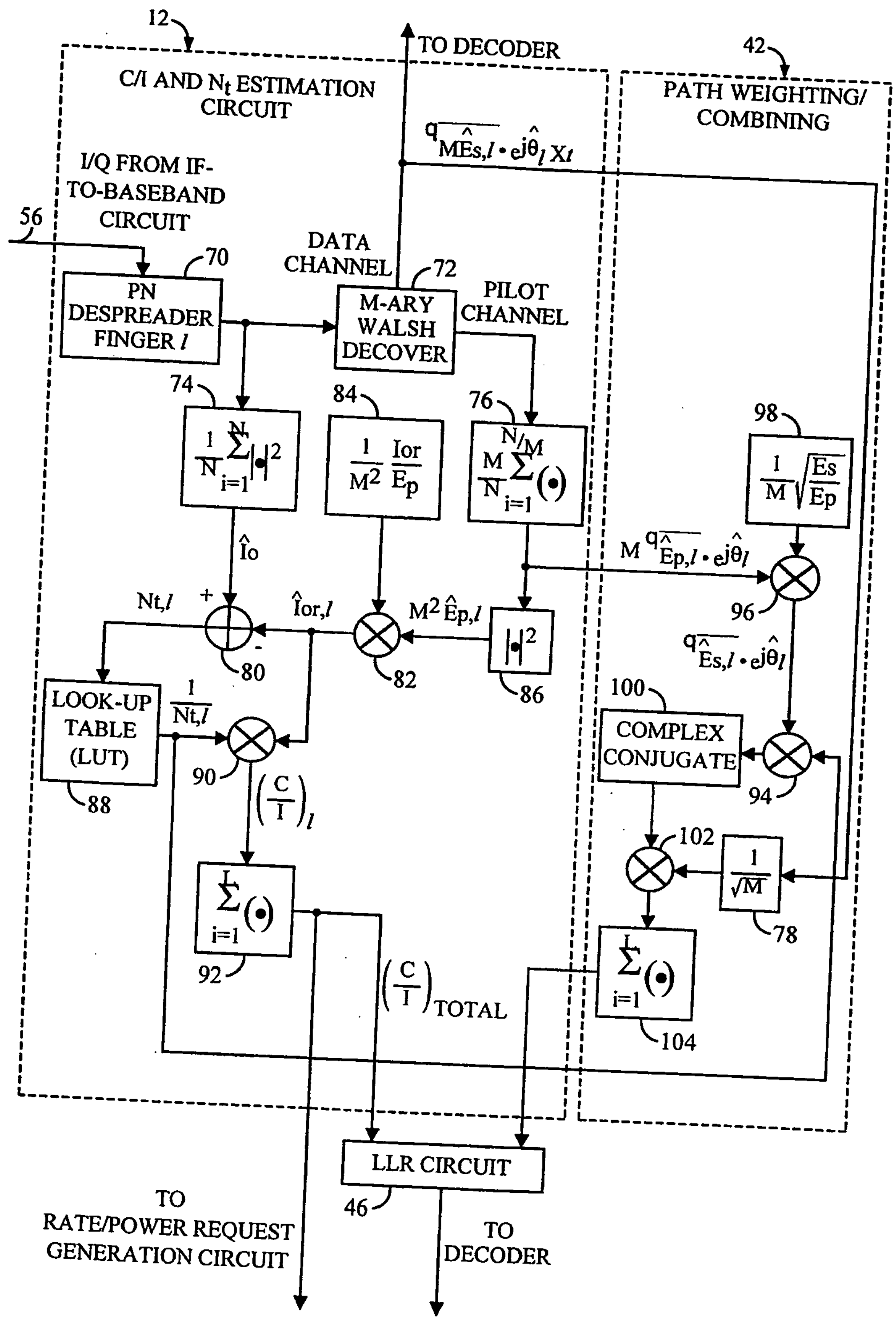
12
C/I AND N_t ESTIMATION CIRCUIT
TO DECODER
42
PATH WEIGHTING/ COMBINING
I/Q FROM IF-TO-BASEBAND CIRCUIT
56
70
PN DESPREADER FINGER l
DATA CHANNEL
72
M-ARY WALSH DECOVER
PILOT CHANNEL
74
84
76
98
$\frac{1}{N}\sum_{i=1}^{N}|\bullet|^2$
$\frac{1}{M^2}\frac{Ior}{Ep}$
$\frac{M}{N}\sum_{i=1}^{N/M}(\bullet)$
$\frac{1}{M}\sqrt{\frac{Es}{Ep}}$
$\hat{I}o$
Nt,l
$\hat{I}or,l$
$M^2\hat{E}p,l$
$|\bullet|^2$
80
82
86
96
100
COMPLEX CONJUGATE
94
LOOK-UP TABLE (LUT)
88
$\frac{1}{Nt,l}$
90
$\left(\frac{C}{I}\right)_l$
102
$\frac{1}{\sqrt{M}}$
78
$\sum_{i=1}^{L}(\bullet)$
92
$\left(\frac{C}{I}\right)_{TOTAL}$
104
LLR CIRCUIT
46
TO RATE/POWER REQUEST GENERATION CIRCUIT
TO DECODER

FIG. 2

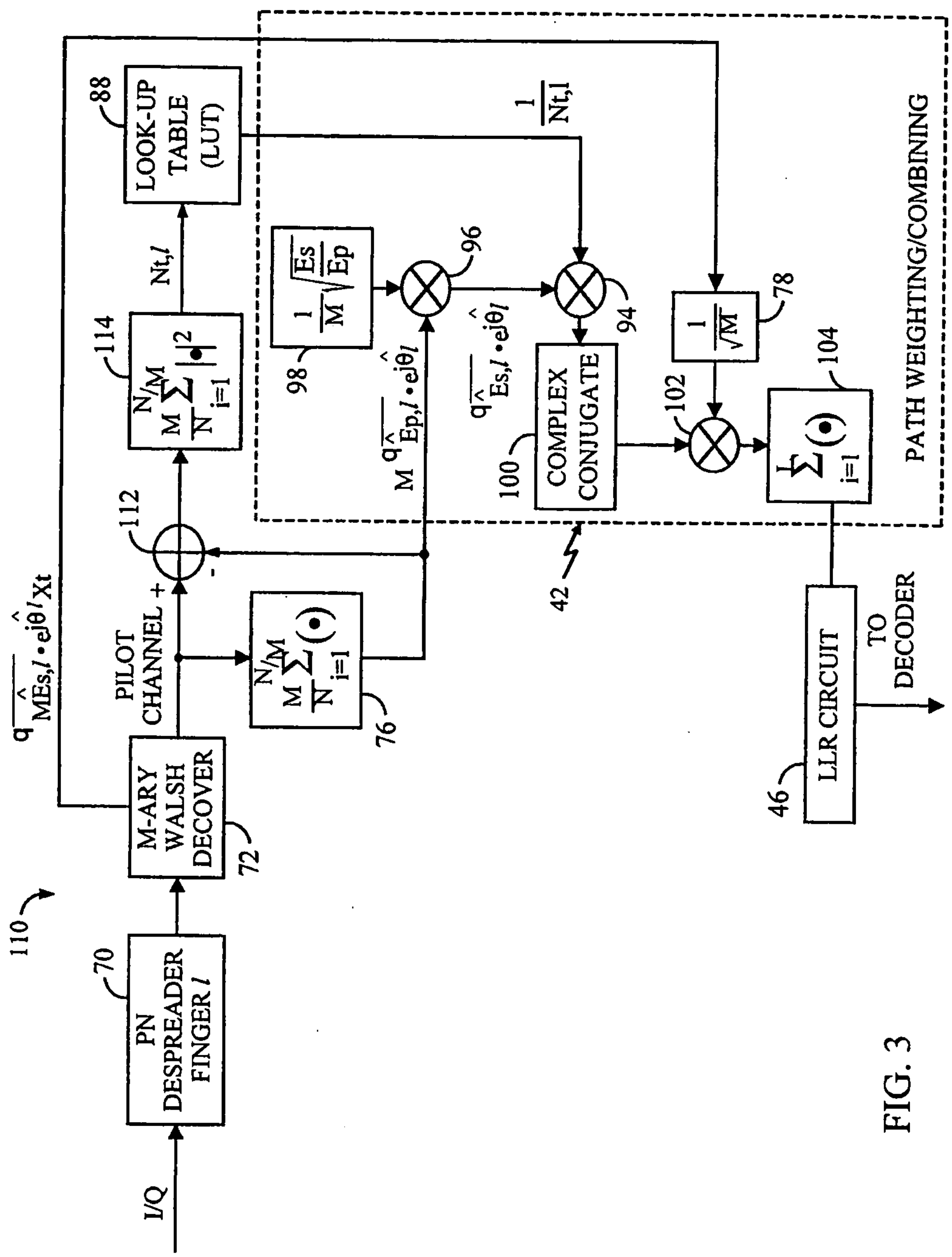
I/Q
PN DESPREADER FINGER l
70
110
M-ARY WALSH DECOVER
72
PILOT CHANNEL
+
-
76
112
114
Nt,l
LOOK-UP TABLE (LUT)
88
1/Nt,l
98
96
94
78
1/√M
100
COMPLEX CONJUGATE
102
104
42
PATH WEIGHTING/COMBINING
46
LLR CIRCUIT
TO DECODER

FIG. 3

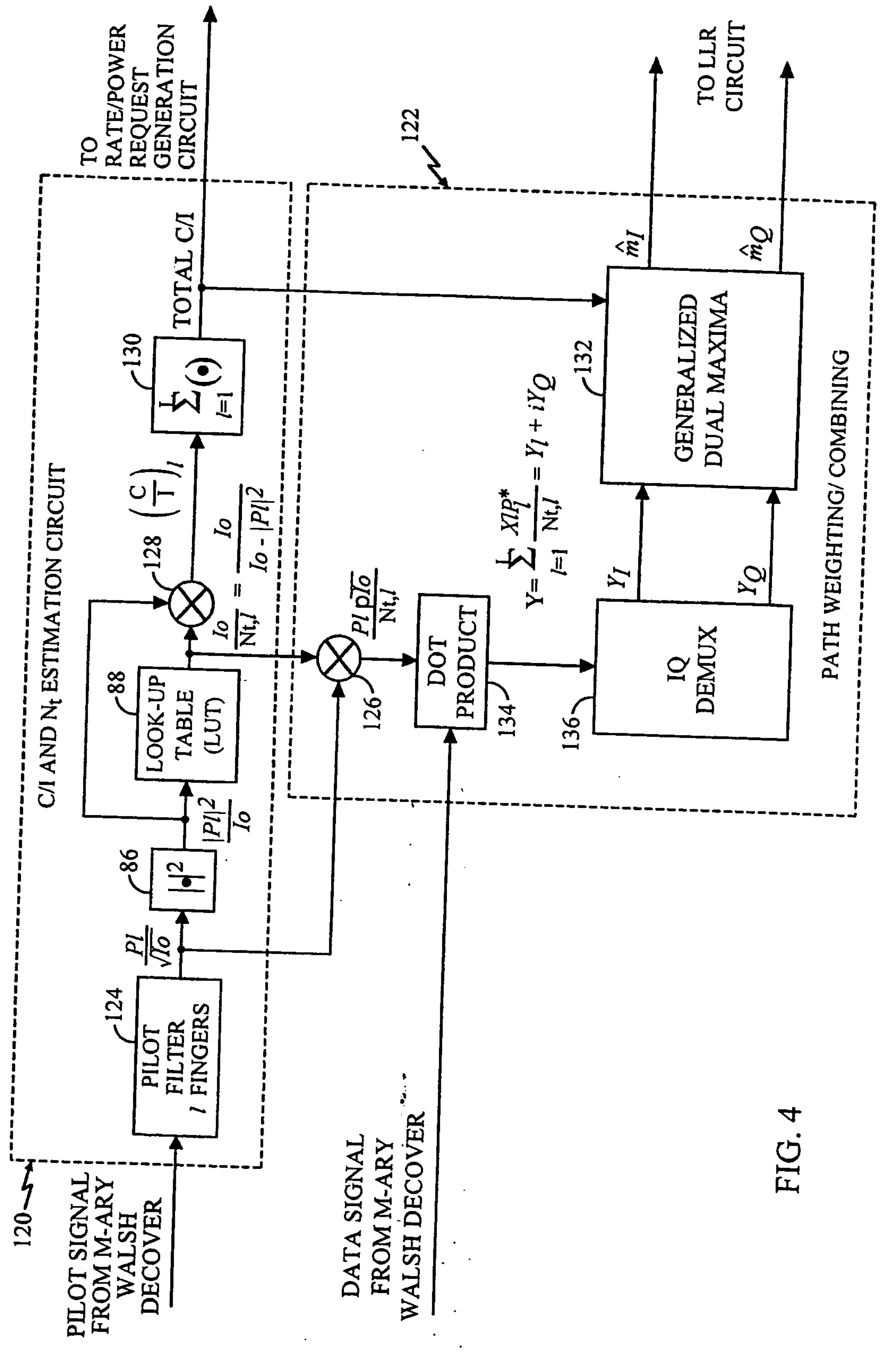
PILOT SIGNAL FROM M-ARY WALSH DECOVER
DATA SIGNAL FROM M-ARY WALSH DECOVER
120
C/I AND Nt ESTIMATION CIRCUIT
124
PILOT FILTER l FINGERS
86
88
LOOK-UP TABLE (LUT)
128
130
TOTAL C/I
TO RATE/POWER REQUEST GENERATION CIRCUIT
122
126
DOT PRODUCT
134
136
IQ DEMUX
132
GENERALIZED DUAL MAXIMA
TO LLR CIRCUIT
PATH WEIGHTING/ COMBINING

FIG. 4

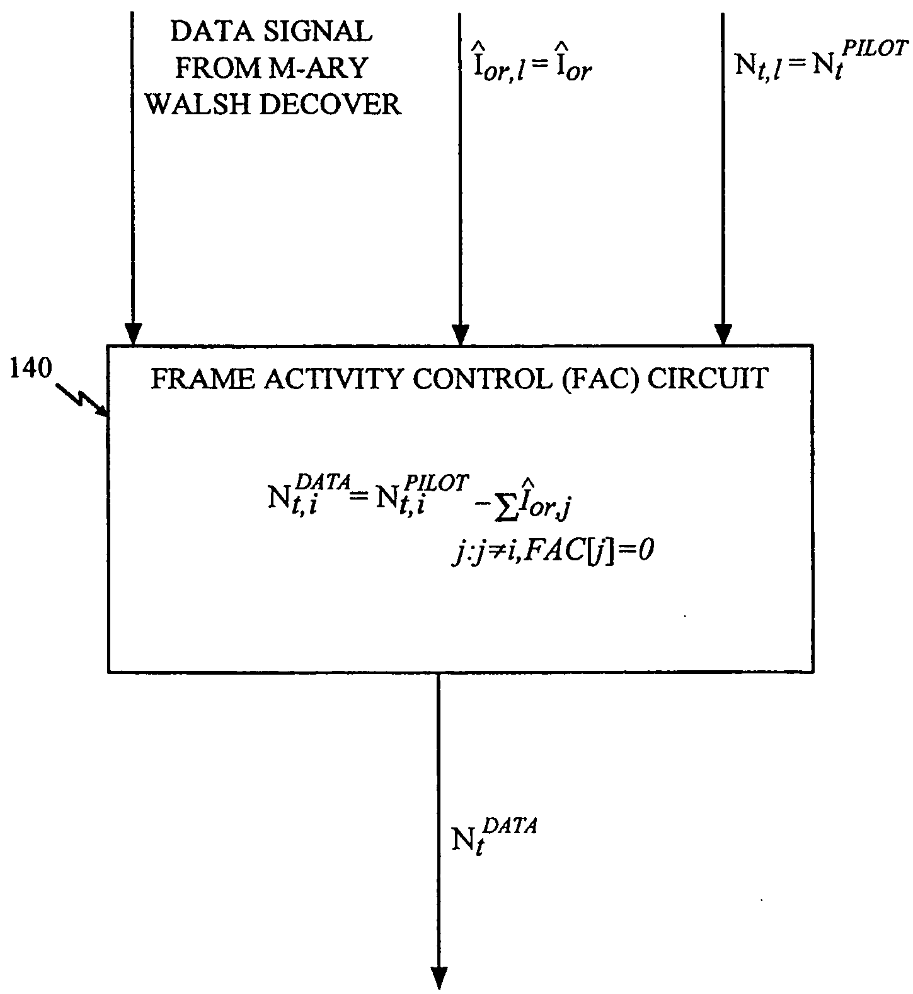
DATA SIGNAL FROM M-ARY WALSH DECOVER
$\hat{I}_{or,l} = \hat{I}_{or}$
$N_{t,l} = N_t^{PILOT}$
140
FRAME ACTIVITY CONTROL (FAC) CIRCUIT
$N_{t,i}^{DATA} = N_{t,i}^{PILOT} - \sum_{j:j \neq i, FAC[j]=0} \hat{I}_{or,j}$
N_t^{DATA}

FIG. 5

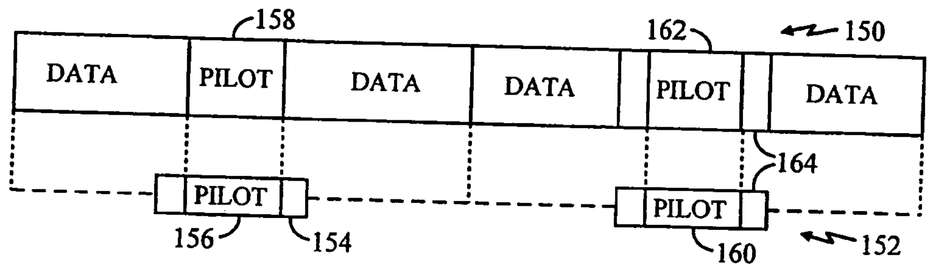
158
162
150
DATA
PILOT
DATA
DATA
PILOT
DATA
164
PILOT
PILOT
156
154
160
152

FIG. 6

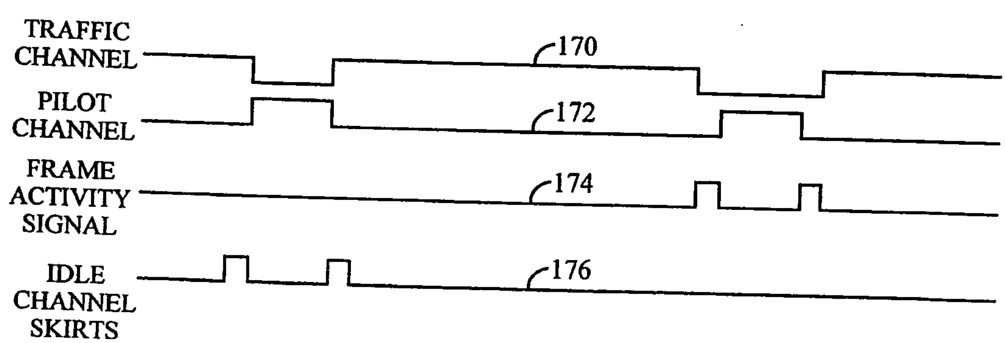
TRAFFIC CHANNEL
170
PILOT CHANNEL
172
FRAME ACTIVITY SIGNAL
174
IDLE CHANNEL SKIRTS
176

FIG. 7